











is 0.20 ppm. This observation suggests that *Chaetoceros Calcitrans* exhibits significant tolerance against Cd<sup>2+</sup> metal ion pollution.

Based on the established permissible threshold of 0.1 ppm for Cd<sup>2+</sup> metal ions in water bodies, it may be inferred that *Chaetoceros Calcitrans* phytoplankton can sustain regular growth even in marine environments contaminated with Cd<sup>2+</sup>

metal ions. This finding demonstrates that *Chaetoceros Calcitrans* has the potential to serve as a bioindicator for marine environments infected with Cd<sup>2+</sup> metal ions. Figure 3 displays the data pertaining to the percentage of growth inhibition (PGI) of *Chaetoceros Calcitrans* in relation to the concentration of Cd<sup>2+</sup> metal ions.

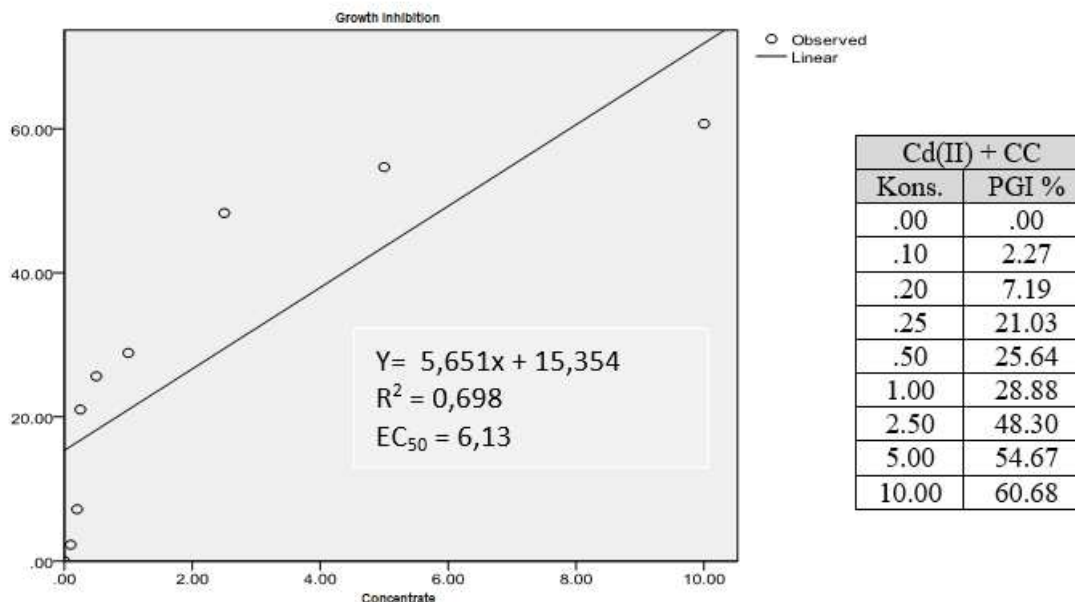


Fig. 3 Relationship between Cd<sup>2+</sup> metal ion concentration and percentage of growth inhibition (PGI) in *Chaetoceros Calcitrans*

The determination of the EC50 price involves plotting the PGI price against the concentration of Cd<sup>2+</sup> metal ions injected, as illustrated in Figure 3. The regression line equation can be expressed as  $y = 5.651x + 15.514$ . The EC<sub>50</sub> price was determined to be 6.13 ppm. The observed ability of *Chaetoceros Calcitrans* to withstand elevated levels of Cd<sup>2+</sup> metal ions suggests that phytoplankton may contribute to the detoxification of Cd<sup>2+</sup> metal ions. The process of detoxifying Cd<sup>2+</sup> metal ions by phytoplankton encompasses a minimum of two sequential steps:

- The activation of *Phytochelatase synthase* (PC synthase) is initiated by elevated intracellular levels of Cd<sup>2+</sup> metal ions, with glutathione (GSH) serving as the substrate.
- Compression and inactivation of Cd<sup>2+</sup> metal ions for inclusion into the cytosol by *Phytochelatins* molecules.

Upon the entry of Cd<sup>2+</sup> metal ions into the cytosol, an intricate mechanism associated with sulfur metabolism is triggered, leading to the synthesis of *Phytochelatins* (PC). When a *cysteine thiolic* group binds to Cd<sup>2+</sup> metal ions, PC forms complexes with these ions (referred to as PC-Cd), thereby inhibiting the movement of free Cd<sup>2+</sup> metal ions within the cytosol. The toxicity of the PC-Cd combination towards numerous plant enzymes is reduced by a factor of 1000 compared to the free metal ion Cd<sup>2+</sup> [71]. Within minutes after the Cd<sup>2+</sup> metal ions supply the enzyme, the process of self-regulation occurs, and PC synthesis continues until the Cd<sup>2+</sup> metal ions are unavailable [72].

The process of PC synthesis has a high rate of speed, resulting in the formation of a complex with low molecular weight (LMW) in the presence of Cd<sup>2+</sup> metal ions. The

presence of Cd<sup>2+</sup> metal ions result in a complex with a greater medium molecular weight (MMW). These two complexes acquire S<sup>2-</sup> ions within tonoplasts, forming high molecular weight (HMW) complexes that exhibit a greater connection for Cd<sup>2+</sup> metal ions. This process facilitates the detoxification of Cd<sup>2+</sup> metal ions. Due to the acidic pH of vacuoles, the HMW complex undergoes decomposition, resulting in the formation of novel complexes, including vacuolar organic acids like citric, oxalic, malic, and amino. Hydrolases in vacuoles can reproduce *Phytochelatins* in reverse reactions to the cytosol [73], [74].

#### IV. CONCLUSION

Based on the aforementioned research findings and treatment outcomes, we conclude that the utilization of Conway medium for the cultivation of marine phytoplankton *Chaetoceros Calcitrans*, at an initial density of 250,000 cells/mL of medium, yields a substantial increase in density, approximately 29-fold, within a mere six-day cultivation period. Furthermore, the introduction of Cd<sup>2+</sup> metal ions at a concentration of 0.5 ppm into phytoplankton culture media of *Chaetoceros Calcitrans* has been observed to result in a reduction in the inhibited growth rate, as well as a drop in both the cell count and dry weight of *Chaetoceros Calcitrans*.

#### NOMENCLATURE

$N_t$	cell density at time t	cell/mL
$N_o$	initial cell density	cell/mL
$\mu$	inhibited growth rate	

t the time (day).  
 PGI percentage of growth inhibition.  
 $\mu_i$  First inhibited growth rate setting  
 $\mu_0$  Control- inhibited growth rate settings.

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